SECURITY CLASSIFICATION: UNCLASSIFIED

LABORATORIES DIVISION

POWER PLANT LABORATORY

TITLE OF REPORT: SIMULATING 60% SLOPE OPERATION BY USE OF SKID-TYPE DYNAMOMETER

REPORT NO. 7224 (I) Final COPY NO. 24

WRITTEN BY David M Latson
David M. Latson

REVIEWED BY Lee A. Smith
Lee A. Smith

DATE OF REPORT: 8 June 1962

SPECIAL PROJECT NO. 2210 WORK ORDER NO. 0479

DETROIT ARSENAL
CENTER LINE, MICHIGAN

ORDNANCE TANK-AUTOMOTIVE COMMAND

SECURITY CLASSIFICATION: UNCLASSIFIED

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DETROIT ARSENAL

Center Line, Michigan

POWER PLANT LABORATORY
Laboratories Division

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SPECIAL PROJECT NO. 2210 WORK ORDER NO. 0479

INITIATION DATE: 15 May 61

WRITTEN BY David M Latson
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ABSTRACT

Report No. 7224

1. Purpose: Determine feasibility and practicability of simulating 60% slope power-train loading by using skid-type dynamometer.
2. Method: Baseline data was recorded from an M48 medium tank during actual 60% slope tests. Hydraulic loading cylinders were used to increase vehicle effective weight in skid dynamometer, and duplication of baseline data was attempted.
3. Results: Simulation was not possible due to lack of strength of skid dynamometer and associated hydraulic equipment.
4. Conclusions: Simulation appears possible but requires modification of dynamometer floor, hydraulic system, and mounting facilities.

DETROIT ARSENAL
Laboratories Division

Report No. 7224 (I) Final

Date: 8 June 1962

PROJECT TITLE: Simulating 60% slope operation by use of skid-type dynamometer

INTRODUCTION

Testing of a product before and during its manufacture is a necessary process to assure that the Government accepts only serviceable equipment. Testing of a complicated unit, such as a tracked vehicle, has always required use of a "proving ground", as well as other equipment. The skid-type dynamometer has been developed and is being refined as one method of removing the requirement of real estate from tracked vehicle testing. This project, which deals with the application of the skid to one requirement of vehicle testing, was initiated at the request of Quality Assurance Division, Industrial Directorate, OTAC.

OBJECT

Determine feasibility and practicability of simulating 60% slope power-train loading by using skid-type dynamometer.

SUMMARY

1. Vehicle was operated on field 60% slope at wide-open throttle, low range. Data was taken to use as base-line information, viz:

a. Vehicle speed, mph.
b. Engine speed, rpm.
c. Intake manifold pressure, in. Hg abs.

2. Vehicle was installed in skid dynamometer and hydraulic pull-down cylinders mounted. It was impossible to duplicate base-line data because:

1. Pull-down loads required could not be obtained with present dynamometer hydraulic system.

2. Modification of the dynamometer floor and mounting system was required to withstand necessary pull-down loads. This modification was not authorized.

CONCLUSIONS

Simulation of 60% slope operation appears possible in the skid dynamometer, but requires:

1. Modification of hydraulic system to obtain greater load capicity.

2. Modification of dynamometer floor to withstand the greater loads.

3. A method of fastening the dynamometer down to prevent distortion under the heavier loads.

TEST MATERIAL

1. M-48A1 Medium Tank, USA No. 9A-8113

2. Production-type skid dynamometer with integral hydraulic system.

The dynamometer consists basically of a smooth skid surface, a system of altering the effective weight of the vehicle, and means of retaining the vehicle on the skid surface. (See Figure 6).

The skid surface is a 1/2-inch thick, mild steel plate. During operation this plate is flooded with 1-1/2 inches of water to lubricate and cool the vehicle tracks.

The method of altering the effective vehicle weight is to use four hydraulic jacks and/or four hydraulic cylinders to either raise or pull down the vehicle. The hydraulic system of the dynamometer consists, then, of these jacks and/or cylinders, along with a motor, pump and reservoir, and appropriate controls.

The vehicle is held on the skid surface by a drawbar at the rear and an arrestor on each side near the front. Experience has shown that the rear bar is highly loaded, but comparatively light side-arrestors will prevent lateral movement.

TEST EQUIPMENT

1. Hydraulic loading cylinders, 15.7 square inches effective piston area in pull direction.

2. Cell 4, Bldg. 212, Detroit Arsenal, with associated instrumentation.

TEST PROCEDURE

1. Operation on 60% field slope.

First echelon maintenance was checked, and vehicle was operated for approximately ten miles to throughly warm up all drive-line components. The vehicle was then driven up a 60% slope at wide-open throttle, low range, and data recorded on the slope after stabilization occurred. Three test runs were made.

2. Operation in the skid dynamometer.

Vehicle was installed in the dynamometer and hydraulic cylinders mounted to hull and skid floor so as to pull vehicle down against the suspension system. Mounting details are shown in Figures 1, 2, 3, 4, and 5, and front view of setup is shown in Figure 6.

Engine and power train were warmed up by operating in low range, wide-open throttle, with only the weight of the vehicle on the suspension system. Hydraulic cylinders were then actuated to increase effective vehicle weight in an effort to duplicate baseline data.

RESULTS AND DISCUSSION

1. Operation of vehicle on 60% slope.

Operation was in accordance with applicable section of Test Procedure. Average values of data taken were:

Engine Speed, rpm	2310
Vehicle Speed, mph	1.5
Gallery Oil Temperature, F	99
Transmission Oil Temperature, F	178
Intake Manifold Vacuum, in. Hg abs	29.00

The vehicle operated in an excellent manner after warm-up and appeared in good condition. The steering adjustment was checked during the warm-up runs and was excellent.

2. Operation in the skid dynamometer.

It was not possible to duplicate the load on the 60% slope in the skid. This was because of insufficient strength in the skid floor and hydraulic system.

The hydraulic system pressure was governed not to exceed 1300 psi. The pull-down cylinders had an effective area of 15.7 square inches; thus the load on each cylinder was 20,410 lb. The total effective load on the suspension system was then:

$$4\ (20{,}410) + \text{vehicle weight} = 178{,}640\ \text{lb}$$

The pull-down load from the cylinders resulted in a downward deflection of 4-5/8 inches at the rear and 3-13/16 inches at the front. A comparison of operating conditions between the slope and skid is shown below:

	Slope	Skid
Engine Speed, rpm	2310	2370
Vehicle Speed, mph	1.5	6.0
Gallery Oil Temperature, F	99	103
Transmission Oil Temperature, F	178	180
Intake Manifold Pressure, in. Hg abs	29.00	28.70

It would appear, at first, that the slope simulation was nearly accomplished, but this was not so. As an aid to explaining the lack of simulation, a set of representative vehicle performance curves are shown in Figure 7. These curves do not represent data taken from the vehicle under test, or any other particular vehicle, but are the results of manufacturer's data and results of other tests on several vehicles and transmissions. The curves are used in the following discussion only to draw some general, comparative conclusions on test results.

The engine speed curve shows that in the 1 to 7 mph range, there was only about a + 40 rpm variation in engine speed. The apparent close duplication of engine speed has little meaning by itself. Of much more significance is the transmission output torque curve governing the same vehicle speed range.

The curves show that for a reduction of vehicle speed from 6 to 1.5 mph under these conditions, an additional 6,500 lb-ft of torque must be absorbed. For an approximation of the effective vehicle load on the suspension system to accomplish this, it is assumed that the torque absorbed is directly proportional to the suspension load. Then:

$$\text{Effective vehicle weight} = \frac{13000}{6500} (178{,}640)\ \text{lb} =$$

357,280 lb

Since the vehicle weighs 97,000 lb, the total cylinder pull-down load would need to be 260,280 lb. This total load represents a load of 65,070 lb per cylinder.

This cylinder loading was not possible for the following reasons:

a. Maximum recommended safe cylinder load is 55,000 lb.
b. Dynamometer floor mounting of cylinders was estimated to be safe only to 40,000 lb.
c. Hydraulic hoses of dynamometer system were not safe at required pressure.

Several operational problems were encountered during the dynamometer test. These problems point out areas requiring future refinement of technique and/or equipment.

a. It was difficult to break both tracks loose with the entire vehicle weight upon them. Experience showed that only one track would operate, and application of some steer was required to get the other track moving. If a set of lift jacks were used, this problem could have been overcome. The ultimate hydraulic system would use a push-pull cylinder of sufficient size to lift the vehicle clear of the floor, as well as provide the 60% slope loading. Cylinders such as these would require modification of both skid and hydraulic system to operate.

b. The large loading required to simulate 60% slope operation results in substantial draw-bar pull. No attempt at calculation was made; however, the original pintle eye connection failed, and a larger one stretched with the loads encountered.

The replacement pintle eye was as large as could be used with the present vehicle pintle. Therefore, modification of the draw-bar is required if slope-loading is to be accomplished.

Written By:

David M Latson
DAVID M. LATSON

Approved By:

for R. E. Prescott
PRESCOTT L. GOUD
Chief, Laboratories Division

Reviewed By:

Lee A. Smith
LEE A. SMITH
Chief, Power Plant Laboratory

DETROIT ARSENAL
Laboratories Division

TECHNICAL REPORT DISTRIBUTION

Date: 8 June 1962

Report No. 7224 (I)
Final

PROJECT TITLE: SIMULATING 60% SLOPE OPERATION BY USE OF SKID-TYPE DYNAMOMETER

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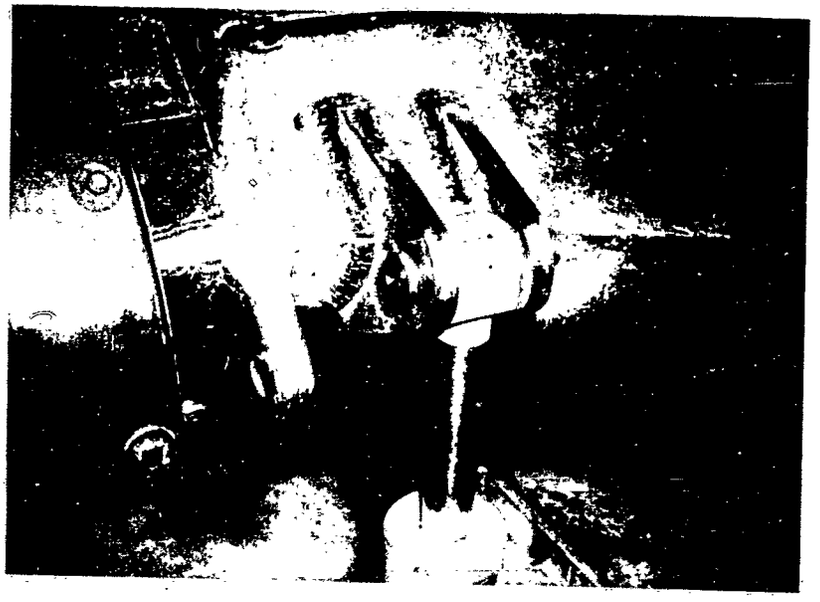
LIST OF INCLOSURES
Report No. 7224 (I)

SKID DYNAMOMETER TEST - REAR LOADING CYLINDER MOUNTING, TOP

Figure 1



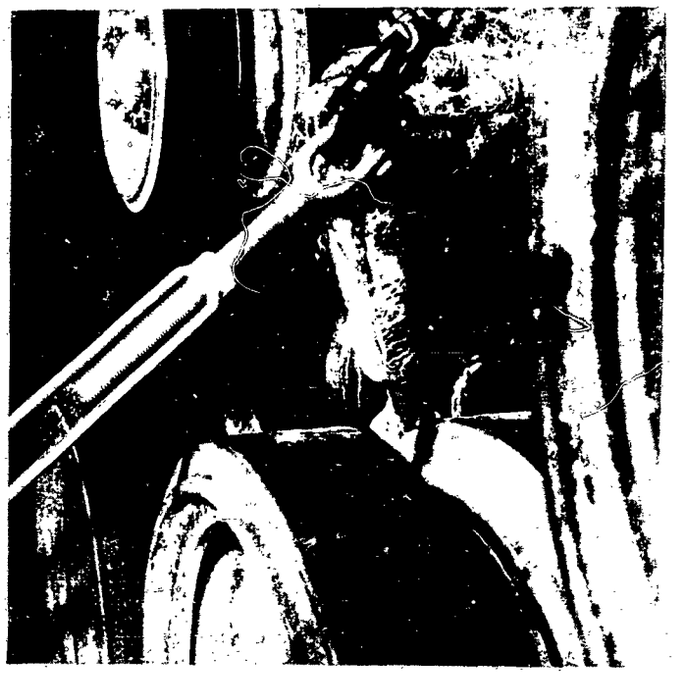
SKID DYNAMOMETER TEST - FRONT LOADING CYLINDER MOUNTING, TOP

Figure 2

Inclosure 1

SKID DYNAMOMETER TEST - FRONT AND REAR LOADING CYLINDER MOUNTING, BOTTOM

Figure 3

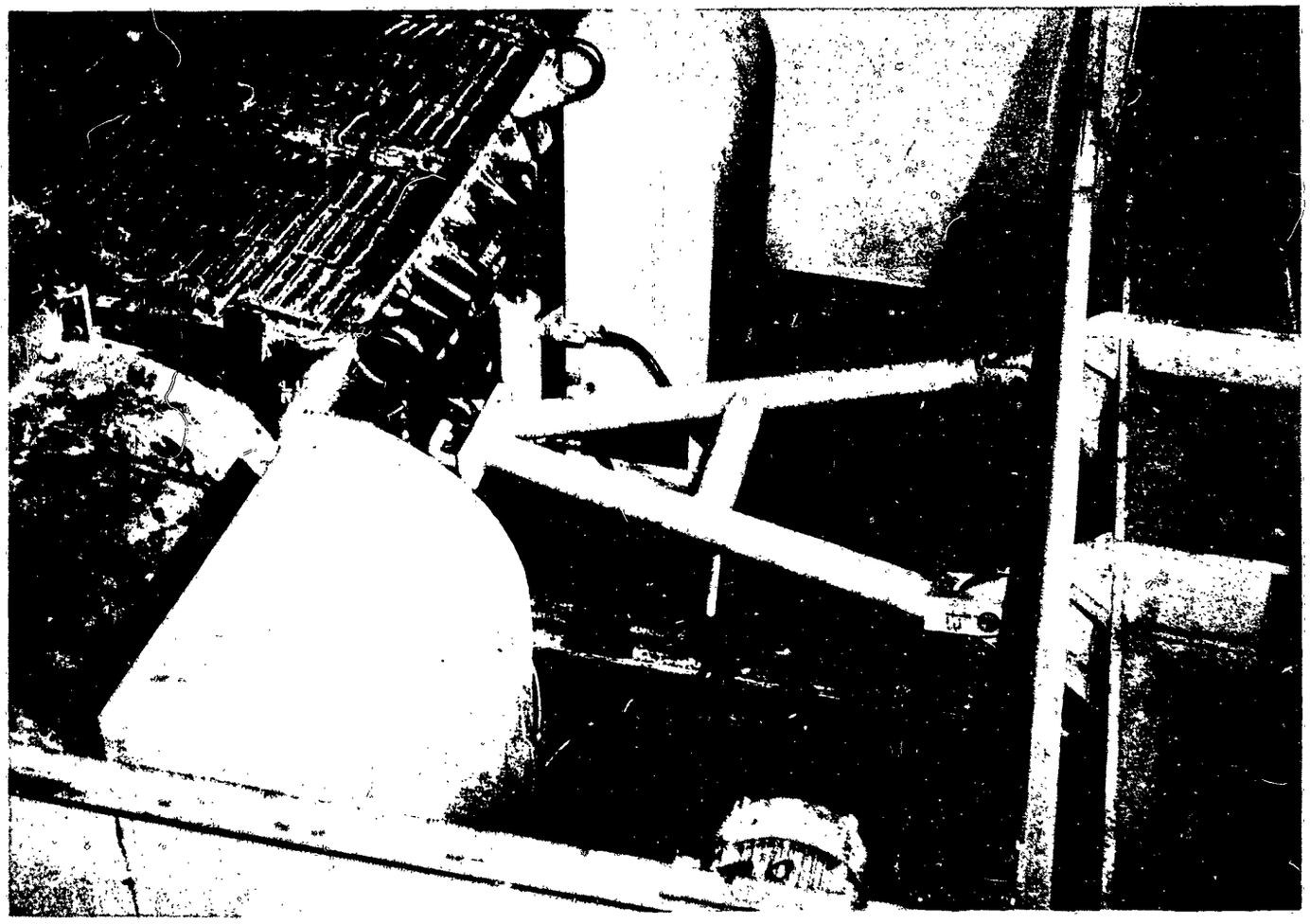


SKID DYNAMOMETER TEST - SIDE ARRESTOR

Figure 4

Inclosure 2

Enclosure 3



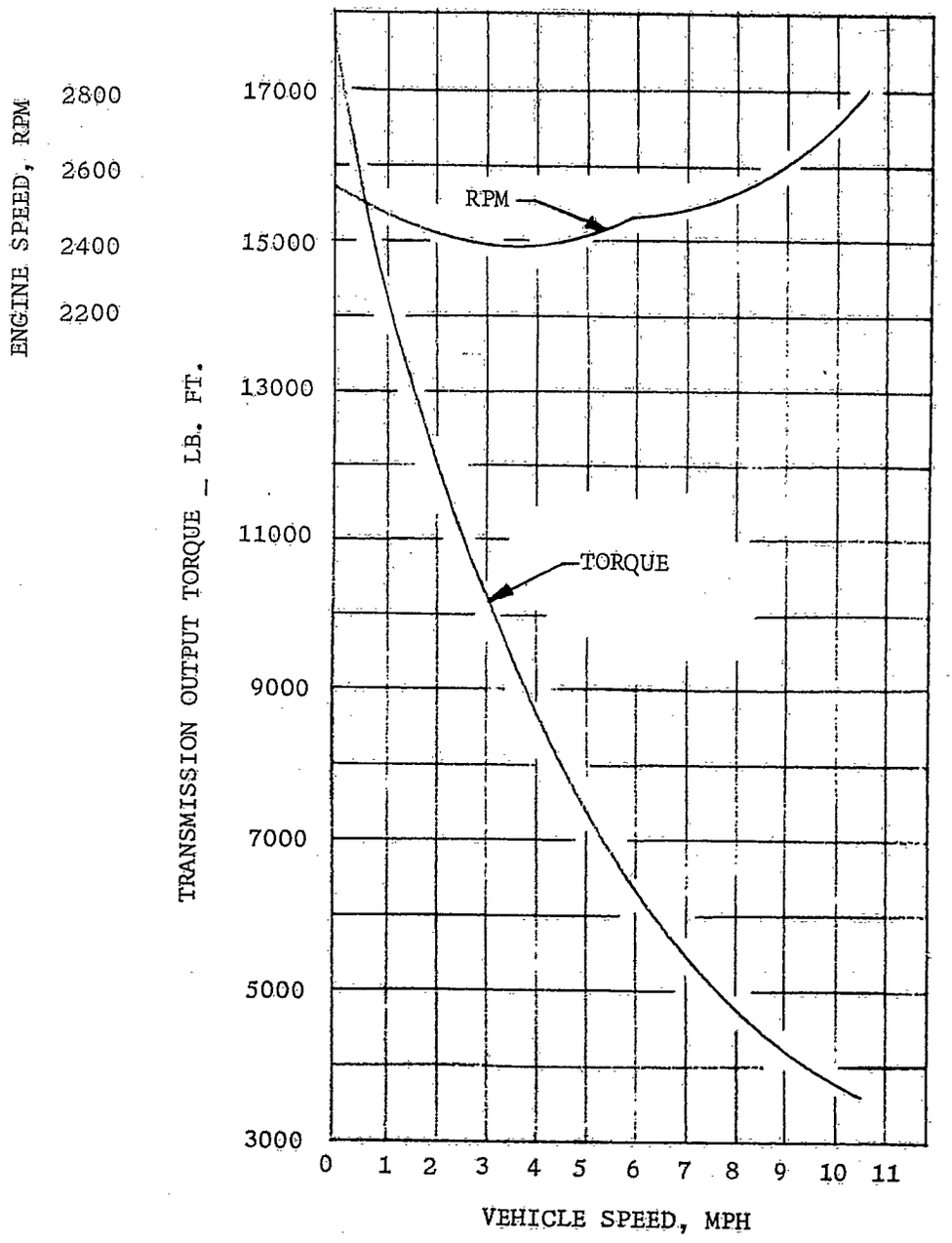
SKID DYNAMOMETER TEST - DRAW BAR INSTALLATION

Figure 5

SKID DYNAMOMETER TEST - TEST SETUP, FRONT

Figure 6

Inclosure 4



REPRESENTATIVE PERFORMANCE DATA FOR M48 MEDIUM TANK (LOW RANGE)

Figure 7

Inclosure 5

DETROIT ARSENAL EXPENDITURE ORDER 1271-0479 — Mr Dracomber/smg/29156

1. TO	TO	2. INDEX NUMBER
E DISTRIBUTION		
3. FROM	**FROM**	**4. REPORT CODE**
ORDMX-OP		

5. OMS CODE & TITLE 2210.4500 (4606)
Alternate Procedures for Acceptance Engineering Test of Combat Vehicles

6. DOCUMENT CONTROL NO.	7. DATE
1-01-043-A42-041-J	15 MAY 1961

8. APPROPRIATE ACCOUNTING CLASS. OF FUNDS (TO BE) MADE AVAILABLE
21X0.0 105-2011 P2210 S20-089

9. PERFORMANCE OF THE FOLLOWING WORK AUTHORIZED (SUBJECT TO AVAILABILITY OF FUNDS)

SUBJECT: EXTENDED DEVELOPMENT OF THE SKID CHASSIS DYNAMOMETER

APPENDIX: IV
PRIORITY: "C"
SPECIAL PROJECT: 2210.
CURRENT SHOP EXPENSE RATES ARE APPLICABLE

FUNDS ARE IN CONFORMITY WITH THE ABOVE REFERENCED PROGRAM AND ARE AVAILABLE FOR FUTURE OBLIGATIONS AND/OR COMMITMENTS IN THE AMOUNT OF

CHIEF, FINANCE & ACCOUNTING BRANCH
5-17-61

(CONT'D NEXT PAGE)

TARGET DATE FOR OBLIGATION

11. A. ELEMENTS	B. QUANTITY (UNITS)	C. UNIT PRICE	D. TOTAL COST
PRIOR			
INCREASE			
DECREASE			
CURRENT			
TOLERANCE			

RECEIVED ADMINISTRATIVE OFFICE ... 1961 ... LABORATORIES DIVISION

12. DELIVERY SCHEDULE AND INSTRUCTIONS

1. THIS IS AN INTEGRAL PART OF AN APPROVED PROJECT, DA 2213, SERIAL NO. 1995 WITHIN WHICH ALL ORDERS ARE IDENTIFIED AS EXPENDITURE ORDER 1271-XXXX. FROM AN ADMINISTRATIVE STANDPOINT, THE EFFECTIVE DATE OF ALL ORDERS WITHIN EXPENDITURE ORDER 1271-XXXX IS DATE OF ISSUE AND THE CLOSING DATE IS DECEMBER 1961.

2. THIS SPECIFIC WORK ASSIGNMENT COVERED BY THIS EXPENDITURE ORDER IS INITIALLY SCHEDULED AS FOLLOWS:

PLANNED STARTING DATE: MAY 1961
TARGET COMPLETION DATE: DECEMBER 1961

3. ANY CHANGES TO THE ABOVE SCHEDULE OR PRIORITY WILL BE REFLECTED WITH APPROPRIATE COMMENT ON THE PRIORITY SCHEDULE SHEETS AND NOT ON THIS EXPENDITURE ORDER.

14. AUTHORIZED BY: POWER PLANT LABORATORY
DATE: 17 MAY 61
SIGNATURE: L. C. Sellmore
TYPED NAME & TITLE: L. C. SELLMORE, DEPUTY COMPTROLLER

DD FORM 1 FEB 60 AOS 20 PREVIOUS EDITIONS ARE OBSOLETE — XD 1271-0479 — PAGE 1 OF 3 PAGES — ATMY-DTAC-Detroit

Incl. 6-1

DETROIT ARSENAL EXPENDITURE ORDER 1271-0479

1. THE PURPOSE OF THIS EXPENDITURE ORDER IS TO PROVIDE FOR DIRECT LABOR AND MATERIAL COST INCURRED IN THE SUPPORT SERVICES TO THE SUBJECT DEVELOPMENT PROGRAM. THIS IS A CONTINUATION OF SERVICES PERFORMED UNDER EXPENDITURE ORDER 3679.

2. THE PROJECT ENGINEER IS MR. S. SOBAK, EXTENSION 33267.

LABORATORIES DIVISION:

1. WILL PROVIDE AND/OR ACCOMPLISH THE NECESSARY ENGINEERING AND FUNCTIONAL REFINEMENT OF SKID CHASSIS DYNAMOMETER AS FOLLOWS:

A. EXTEND USE OF SKID CHASSIS DYNAMOMETER TO INCLUDE POWER TRAIN LOADING CONDITIONS TO SIMULATE GRADE CITED IN APPLICABLE TRACKED VEHICLE SPECIFICATIONS.

B. DEVELOP ADDITIONAL PARAMETERS TO SIMULATE STEERING CONDITIONS. PROVIDE TEST SPECIFICATIONS AND OPERATING PROCEDURES TO GOVERN ACCEPTANCE OF TRACKED VEHICLES ON THE DYNAMOMETER.

C. INCORPORATE INTO EXISTING EQUIPMENT RECOMMENDED CHANGES DETERMINED FROM PREVIOUS TEST RESULTS REFERENCED IN LAB REPORT 4518 (FINAL).

(1) DEVELOP AND INSTALL VEHICLE ALIGNMENT DEVICE TO REDUCE POSITIONING TIME.

(2) DEVELOP AND INSTALL A SIGNAL DEVICE TO RELAY WARNING SIGNALS FROM THE INSTRUMENT PANEL TO OUTSIDE OPERATOR.

(3) INSTALL REDUCED DIA JACKS TO LOWER PSI REQUIREMENT AND INCREASE LIFTING CAPACITY APPROXIMATELY 3". ACCOMPLISH REDUCTION OF OIL RESERVOIR.

2. REPORTS REQUIRED:

Incl. 6-2

DETROIT ARSENAL EXPENDITURE ORDER 1271-0479

FINAL TECHNICAL REPORT TO ORDMC-IF THROUGH ORDMX-OP.

3. FY 1961 PROGRAM AUTHORITY:

"01" "99"

REFERENCES: AOS-20, #230-61.
DA FORM 2213, SERIAL #1995.
ORDMX-BO COST ESTIMATE #1380-1.

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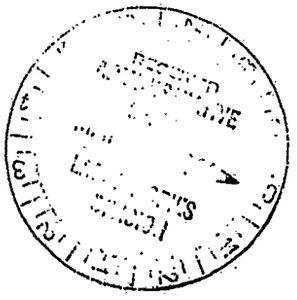

Incl. 6-3

AD ______ Accession No. ______

Power Plant Laboratory, Laboratories Division, Detroit Arsenal
SIMULATING 60% SLOPE OPERATION BY USE OF SKID-TYPE DYNAMOMETER
Mr. D. M. Latson JUN 8 '62

Report No. 7224 (I) Final- 7 pp Illus - photographs and graphs - Special Project No. 2210, Unclassified Report

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2. Method: Baseline data was recorded from an M48 medium tank during actual 60% slope tests. Hydraulic loading cylinders were used to increase vehicle effective weight in skid dynamometer, and duplication of baseline data was attempted.
3. Results: Simulation was not possible due to lack of strength of skid dynamometer and associated hydraulic equipment.
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-Unclassified-

Vehicle, Model
M48 Medium Tank

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